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DECLARATION

The undersigned, Jan McLin Clayberg, having an office at 5316 Little Falls Road, Arlington, VA 22207-1522, hereby states that she is well acquainted with both the English and German languages and that the attached is a true translation to the best of her knowledge and ability of

the specification of German Patent Application 102 00 304.1, filed January 7, 2002.

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.

Jan McLin Clayberg

LAMP

The invention relates to a lamp which has a base at one or two ends and includes a bulb element, which is disposed on the at least one base and essentially envelops a physical volume. At least one LED element (Light Emitting Diode) is associated with the lamp.

One such lamp is known from German Patent Disclosure DE 198 29 270 A1. The lamp described there includes at least two lamp elements of different color temperature; the total color temperature of the lamp is variable. One of the lamp elements is embodied as an LED.

When LEDs are disposed in a lamp, the fact that LEDs typically emit directed light must be taken into account. To attain uniform distribution of the luminous flux density, or luminance, of the LED light emitted by the lamp, a special disposition of the LED elements is necessary. The goal is largely to avoid a breakdown into light source structures for an observer. In a lamp with two lamp elements of different color temperature, shading problems furthermore play a special role.

The object of the invention is to develop a lamp having at least one LED element such that homogeneous distribution of the luminance of the LED light emitted by the lamp is attained.

This object is attained according to the invention in that the LED light is irradiated into the bulb element, and because of reflection, especially total reflection, at boundary faces of the bulb element, the LED light is carried onward inside the bulb element.

The principle of the invention is thus essentially that light emitted by one or more LED elements is injected directly into the bulb element, and the bulb element is used as a light-guiding and/or light-deflecting element. In this way, the entire bulb element can be supplied with LED light or have LED light flowing through it largely uniformly. By the disposition and embodiment of corresponding boundary faces and a suitably selected shape of the bulb element, care can be taken to assure that the LED light emerges from the bulb element largely uniformly and leaves the lamp in that way.

According to the invention, a breakdown into light source structures can be avoided. Moreover, in the case where a lamp element of the second type is disposed inside the physical volume, a total light distribution which is generated jointly by the at least one LED element and the lamp element of the second type can be achieved which does not cause any shattering problems. The LED element and the lamp element of the second type advantageously generate an identical luminance distribution.

In the lamp according to the invention, it is possible for the bulb element to have exclusively curved, or in other words maximally edge-free boundary faces, so that a predominantly continuous course of the light intensity distribution becomes possible.

LED light is generally understood to mean the electromagnetic radiation in the visible wavelength range emitted by an LED element. However, in the sense of the present invention, the term LED light also includes radiation in the non-visible wavelength range, for instance including

UV radiation, emitted by the LED element.

The wording according to which it is provided that the bulb element essentially envelops a physical volume naturally also covers exemplary embodiments which have openings in the bulb element. For example, these openings may be vent openings, which allow a cooling flow of air to pass through the bulb element. For the case where such openings in the bulb element are provided, special further provisions may be made for carrying the LED light onward inside the bulb element.

A bulb element per se is known and in wide use in lamps of the prior art. In the prior art, the bulb element basically serves to keep a defined gas inside a physical volume. On the other hand, by means of the fixed connection of the bulb element to the at least one base, an enclosed cavity can be achieved, in which a different pressure prevails from that outside the lamp. In addition to this function, it is also already known in the prior art to use a bulb element as a diffuser.

According to the invention, the bulb element is now assigned the function of a fiber optic conductor for the light emitted by the at least one LED element. This makes it possible to guide the luminous flux of the LED in a targeted way such that virtually the entire outer boundary face of the bulb element can function as a light exit face, for largely uniform emergence of the LED light from the bulb element.

The conventional, known functions of the bulb element in the sense of a diffuser or in the sense of a pressure chamber wall or gas chamber wall do not have to be given up but instead can also be adopted.

In this connection, it is advantageous if, in one embodiment of the invention, the physical volume is enclosed completely, jointly by the bulb element and the at least one base. In this way, a different pressure can prevail inside the physical volume from that in the exterior of the lamp, and/or the physical volume can be filled with a gas.

In a further advantageous embodiment of the invention, the at least one LED is disposed in the at least one base of the lamp. This makes it especially simple to accommodate the LED elements.

In a further advantageous embodiment of the invention, two or more LED elements are disposed in the region of the periphery of the base. Once again, this makes it simple to accommodate the LED elements. This arrangement is also favorable with regard to temperature distribution, especially if a lamp element of the second type is disposed in the lamp. In this way, simultaneous operation of different lamp elements is possible in particular, with at most only slight mutual temperature influence.

The base of an LED element heats up to a comparatively great extent. Particularly in the case of a lamp element of the second type in the form of a compact fluorescent lamp, comparatively high temperatures also occur in the region where this lamp element is connected to the base. By disposing the LED element or elements in the region of the outer periphery of the base and disposing the lamp element of the second type approximately centrally on the base of the lamp, maximum spacing is achieved between the region where the LED elements are disposed and the region where the lamp element of the second type is connected. By means of this

large spacing, a maximum reduction can be achieved in the extent to which the lamp elements influence each other's temperature, making parallel operation of both lamp elements possible. Dissipation of the heat generated by the LED elements to outside the base can be done almost without any disruption from the compact fluorescent lamp.

In a further advantageous embodiment of the invention, the at least one LED element is disposed on the at least one base near the region where the bulb element is secured. In this way, the LED light emitted by the at least one LED element can be injected directly into the bulb element with virtually no losses.

In a further advantageous embodiment of the invention, a lamp element of the second type is disposed in the physical volume. This makes it possible to embody a lamp with two lamp elements of different color temperature, as described in DE 198 29 270 A1. In particular, it is possible to provide the LED elements as lamp elements of the first type having a first color temperature, and to dispose at least one lamp element of the second type, having a different color temperature, in the enveloped physical volume. In this case, one of the two lamp elements or groups of elements can advantageously be designed such that they can be dimmed and/or can be turned on and off.

In a further embodiment of the invention, two or more LED elements which are distributed in the circumferential direction on the base are provided. This makes it possible to achieve high light output for the light emitted by the LEDs, since many LED elements can be arranged such that they are packed comparatively tightly together.

The number of LED elements is limited in practice only by the dimensions of the base. However, by disposing two or more LED elements essentially in the form of a circular ring, a particularly dense arrangement can be selected, so that a high luminous flux of LED light can be injected into the bulb element.

In a further embodiment of the invention, the LED elements include different colors. In this way, for example by selectively dimming the LED elements, a color drift can be attained.

In a further advantageous embodiment of the invention, in addition to the at least one LED element, lamp elements of the second type are provided which have essentially the same color temperature as the LED element. Such a combination is expedient, for example for generating efficient emergency light or continuous light with a low light output, and if necessary additionally actuating the lamp element of the second type, for example in the form of a compact fluorescent lamp, in order to generate a high luminous flux.

In a further advantageous embodiment of the invention, the bulb element has an inner boundary face which is adjacent to the physical volume, and an outer boundary face which is adjacent to the exterior, and the inner and outer boundary faces are at least partially curved. This embodiment makes bulb elements with largely no edges possible, so that in principle, a uniform light exit face for the bulb element can be created.

The LED light is passed on within the bulb element along the boundary faces largely by total reflection at the two boundary faces. Light is made to emerge from the bulb

element essentially through imperfections or by means of suitable surface machining, such as roughening, or by a special coating of the boundary faces. Providing the bulb element with a particular shape or forming or machining the boundary faces can assure that imperfections are created on the boundary faces such that in each case, on its way through the bulb element, some of the LED light passed on within the bulb element is diffused at the imperfections and emerges from the bulb element, but by far the great majority of the LED light is passed on within the bulb element.

It could be conceivable for example to provide imperfections that increase in number with increasing spacing from the LED element. Alternatively, a corresponding light distribution could also be achieved by means of machining the surface of the outer boundary face to a different extent, depending on the spacing from the LED element.

In a further advantageous embodiment of the invention, a diffuser element is provided in addition to the bulb element. In this case, the diffuser element may likewise be in the form of a bulb and can for instance envelop the bulb element. Such a diffuser element contributes to making the LED light more homogeneous.

In an advantageous embodiment of the invention, the bulb element is solid and has an essentially constant wall thickness between the inner and outer boundary faces. The imperfections may in this case be disposed in the bulb element itself, for example by introducing intentional impurities.

Alternatively, provision is made for varying the wall thickness of the bulb element, in particular as a function of

the spacing from the LED elements.

In a further advantageous embodiment of the invention, the entire bulb element is hollow, and separate structural elements form the inner boundary face and the outer boundary face, and total reflection occurs at the inner and outer boundary faces. Between the two boundary faces, there may be a vacuum or a gas filling.

In an advantageous embodiment of the invention, the inner and/or outer boundary face of the bulb element is provided with a fluorescent layer which is stimulated by the LED light, in particular by LED radiation which is in the short-wave UV range.

In a further advantageous embodiment of the invention, the lamp has at least one base of conventional physical shape, as described in DE 198 29 270 A1. This offers advantages, particularly when the lamp according to the invention is connected to conventional light fixtures.

In the drawings:

Fig. 1 shows a schematic view, partly in section, of a first exemplary embodiment of a lamp according to the invention having a conventional, bulb-shaped basic form;

Fig. 2 shows a schematic, fragmentary sectional view of one end region of a second exemplary embodiment of a lamp according to the invention, in the form of a lamp having a base at two ends with two types of lamp element;

Fig. 3 shows a third exemplary embodiment of the invention, in the form of a lamp which has a base at one end

and has two types of lamp element.

Fig. 1 shows a lamp, represented overall by reference numeral 10, which has a bulb element 11 of a conventional, bulb-shaped or teardrop-shaped basic form. The bulb element 11 is secured to a base 12, which is embodied as a screw base and serves the purpose of mechanically holding the lamp and electrically connecting it to a light fixture fitting (not shown).

The bulb element 11 envelops a physical volume 14, which can for example be evacuated or, as an alternative, can be provided with a gas filling. It is possible for a lamp element of the second type to be disposed in the physical volume 14. In principle, it is also possible for there to be a direct connection between the physical volume 14 and the exterior 15 of the lamp, the bulb element 11 and/or the base 12 having air passage openings.

In all the exemplary embodiments, the bulb element 11 comprises a light-conducting material, such as glass or plastic. It has an inner boundary face 16 and an outer boundary face 17. The inner boundary face 16 represents the side, facing the bulb element 11, of the boundary layer between the bulb element 11 and the volume element 14, and the outer boundary face 17 represents the side, facing the bulb element 11, of the boundary layer between the bulb element 11 and the exterior 15 of the lamp.

The bulb element 11, which in the exemplary embodiments comprises a solid material, may alternatively also comprise two separate elements, such that the inner boundary face 16 is furnished by a first element, and the outer boundary face 17 is furnished by a second element. Between the boundary

faces, an airless or gas-filled space can then be provided, through which the diode light is propagated.

In the exemplary embodiment of Fig. 1, only one LED element 13 is shown in the region of the base 12, for the sake of clarity. Preferably, two or more LED elements 13 are disposed, distributed uniformly over the circumference, in the region of the base 12 of essentially circular cross section, around the longitudinal axis L of the lamp 10, so that an essentially circular-annular disposition of LED elements is created.

In Fig. 1, the LED element shines the LED light directly from below into the peripheral region 28 of the bulb element 11 along the course of the arrow 18. In the region where the light is shone in or in other words irradiated, it is understood that care must be taken that the least possible irradiation losses occur here, so that maximum LED light 18 is available for uniform illumination of the exterior 15 of the lamp.

The LED light is propagated along the course of the arrow 18 in the bulb element 11. At the inner and outer boundary faces 16, 17, total reflection occurs. The course of the arrow 18 is meant to illustrate the path of the diode light merely schematically. In actuality, a virtually infinitely large number of different arrow courses 18 are superimposed on one another.

In the region 20 of the outer boundary face 17, the outer boundary face 17 is embodied in a special way. For instance, surface machining of the exterior 23 or a special course of the outer boundary face 17 can be achieved here, so that here the LED light 18 exits from the bulb element 11

into the exterior 15. This is meant to be represented by the arrow 19. Alternatively, instead of surface machining, a special coating of the exterior 23 can be done, for instance including with fluorescent substances that convert short-wave LED radiation into visible LED light. Finally, it is also possible to attain a suitable light exit by means of a suitable shaping of the bulb element itself.

In a corresponding way, the inner boundary face 16 can also be embodied, as indicated by the region 22, for example, so that here some of the LED light does not undergo total reflection at the inner boundary face 16 and conduction onward but instead, along the arrow 21 shown, exits from the bulb element 11 into the exterior 15.

The boundary faces 16, 17 are preferably embodied over their entire length such that all the LED light fed into the bulb element 11 from all the LED elements 13 exits uniformly, or at least largely uniformly, from the bulb element 11. In this way, the bulb element 11 is perceived by an observer to be a largely homogeneous light source, without the individual LED elements being apparent.

At this point, it is noted in particular that the embodiment according to the invention of the boundary faces 16, 17 can be achieved for instance by means of special coatings, or by machining, for instance by roughening the material of the bulb element 11. The inside 33, facing the physical volume 14, of the bulb element 11 is accessible from the physical volume 14, so that the bulb element 11 in its finished form can still be machined further, to vary the inner boundary face 16. The completely freely accessible exteriors 23 of the outer boundary faces 17, which can likewise be coated or be machined, are even simpler to

machine.

The above-described light emergence represented by the arrows 19 and 21 is meant to illustrate the light path only schematically. In fact, light emergence from the bulb element 11 comes about in the area of regions 20, 22 of the kind where imperfections are present in the boundary faces 16, 17, or imperfection-like inclusions are present in the bulb element 11. For achieving maximally homogeneous light distribution of the LED light 18 throughout the entire bulb 11, such regions 20, 22 that include imperfections are understood not to be distributed only at some points over the bulb element 11 but instead to cover it virtually completely. Solely by means of the density of the imperfections, or their embodiment, is it successfully possible to attain a light distribution of the LED light 18 that is maximally homogeneous over the entire length of the bulb element 11.

Finally, it is also conceivable, although more complicated, to achieve the desired uniform light emission of the LED light 18 from the bulb element 11 by means of a special shaping of the bulb element 11. For instance, the thickness d of the bulb element 11, that is, the wall thickness of the bulb element 11, or in other words the spacing between the inner boundary face 16 and the outer boundary face 17, which in the exemplary embodiment of Fig. 1 is constant, can be varied over the entire length of the boundary faces 16, 17.

Fig. 2 shows a second exemplary embodiment of a lamp 10 according to the invention, which has a base on two ends. It thus takes the form of conventional fluorescent lamps.

Fig. 2, in only a fragmentary view, shows an end region

of this lamp 10 with a base 24 and corresponding terminal contact pins 25. An identical base 24, not shown, is located on the opposite, right-hand end of the lamp 10 in terms of Fig. 2.

The two bases 24 are connected to a bulb element 11, which is of conventional, hollow-cylindrical basic shape with a circular cross section. In conventional fluorescent lamps, the known bulb element is typically of glass.

An incandescent coil 26 is associated with the base 24. A fluorescent layer 32, not shown in further detail, is disposed here on the inside 33, facing the interior 14, of the bulb element 11.

The incandescent coil 26 with the appropriate terminals, the gas 27, and the fluorescent layer 32 together form a lamp element 31 of the second type, which will be described in further detail hereinafter. In such fluorescent lamps, the bulb element 11 typically serves solely as a protective bulb or for containing the gas 27.

In the lamp 10 of Fig. 2, analogously to the exemplary embodiment of Fig. 1, the bulb element 11 has an inner boundary face 16 and an outer boundary face 17. The bulb element 11 is secured directly to the base 24, creating a substantially circular-annular securing region 28. In the exemplary embodiment of Fig. 2, many LED elements 13 are again disposed on the base 24, near the securing region 28, and are spaced apart uniformly from one another in the circumferential direction. In Fig. 2, only two LED elements 13 are shown, which feed the LED light into the bulb element 11 as indicated by the course of the arrow 18. The terminals for the LED elements are not shown.

Inside the bulb element 11, a total reflection again occurs at the two boundary faces 16, 17, so that the LED light 18 is propagated along the entire length of the bulb element 11.

Analogously to the exemplary embodiment of Fig. 1, the LED light 18 exits from the bulb element 11 into the exterior 15 as indicated by the arrows 19, 21, which is achieved by means of a suitable embodiment of the boundary faces 16, 17. The machining or coating or embodiment of the bulb element 11 can be done here analogously to the way described in conjunction with Fig. 1.

The exemplary embodiment of Fig. 2 thus has lamp elements of a first type, namely the group of LED elements 13. A lamp element 31 of a second type is furthermore provided, which is at least very greatly similar to a conventional fluorescent lamp. In the event that, as provided in Fig. 2, the group of lamp elements 13 of the first type comprises two or more individual elements (LED elements 13), it can also be possible to trigger the individual elements separately from one another.

For instance, it is conceivable for individual lamp elements to be switched on or off during the operation of the respective other lamp element, or for at least one of the two lamp elements of different groups to be embodied as capable of being dimmed. In this way, an efficient emergency or continuous light of a low-power lamp can be possible, for instance furnished solely by LED elements. On the other hand, in this way a total color temperature change can also be attained, for the purposes described in DE 198 29 270 A1.

At this point, it is also noted that it is understood that, in the physical volume 14 of the first exemplary embodiment of Fig. 1, a lamp element 31 of the second type, not shown there, may be disposed. The type of lamp element 31 of the second type is in principle initially arbitrary. For instance, it may be a compact fluorescent lamp. It should also be noted that the bulb element 11 of the exemplary embodiment of Fig. 2 here takes on the function of both a fiber optic conductor for the LED light 18 and the function of a protective bulb. In principle, a separate diffuser element (which is not shown) can furthermore be provided, which envelops the entire arrangement. Finally, it is also conceivable for an arrangement, in particular a concentric arrangement, of two bulb elements to be provided, the one bulb element forming a protective bulb and the other bulb element serving to carry the LED light 18 onward.

Fig. 3 shows a third exemplary embodiment of the lamp 10 of the invention, with a bulb element 11 that is U-shaped in cross section and is rotationally symmetrical with respect to its longitudinal axis L. The lamp 10 of Fig. 3 again has a base on only one end, by means of a base 29. Once again, the base 29 has various connection elements 30, which serve the purpose of both mechanically and electrically connecting it to a fitting, not shown, on a light fixture. The statements made in conjunction with Figs. 1 and 2 apply equally to the exemplary embodiment of Fig. 3.

Analogously to the exemplary embodiment of Fig. 2, lamp elements 31 of the second type are disposed in the physical volume 14 of the bulb element 11, which is closed and is solidly connected to the base 29. LED elements 13 are again disposed in the base 29 and spaced apart from one another, distributed in the circumferential direction. The LED

elements 13 and the two lamp elements 31 of the second type can, in a way similar to the exemplary embodiment of Fig. 2, have a different color temperature. In this way, the object stated in DE 198 29 270 A1 of creating a lamp with two lamp elements of different color temperature, in which the total color temperature of the lamp is variable and a variation in the lighting level of the color temperature is effected, can be equally advantageously attained. The LED elements 13, as lamp elements of the first type, and the lamp elements 31 of the second type, which may for instance be embodied as a compact fluorescent lamp, or as a high-pressure discharge lamp, may, however, also have the same color temperatures. At least one of the two lamp element groups or lamp elements 31, 13 can preferably be dimmed and/or turned on and off.

The propagation of the LED light 18, in the exemplary embodiment of Fig. 3, is effected analogously to the light propagation described above.